Course Name:	Groundwater Flow and Contaminant Transport
Course Number:	CE502
Credits:	03
Prerequisites:	Prerequisite is Water Resources engineering and background knowledge of programing
Intended for:	UG/MS/PhD
Elective or Core:	Elective
Distribution:	1L: 1T: 1P
Semester:	Even/Odd

Preamble:

Groundwater contamination and transport has become a burning issue due to increasing chemical wastes. Industrialization, civilization, climate change and increasing population are the some prominent reasons of surface water scarcity, quality degradation. To fulfil the water demand of society, industries etc. one has to explore the subsurface water system. Groundwater is a great source of clean water, however due to aforesaid reasons groundwater quality is deteriorating day by day. Once contaminated it is very difficult and costly to remediate the groundwater. Also groundwater can carry poisonous heavy metals, salts, pathogens, bacteria etc. Groundwater contamination and flow is very challenging problem to solve for groundwater hydrologists due to chemical properties of contaminants and its interaction with porous media.

Modeling of ground water contamination can help in understanding to explore the non-harmful sources of groundwater. Due to which it becomes essential to introduce to students at PG level.

Learning outcomes of this course are anticipated as follows:

- Students will understand the basics of groundwater flow, aquifer system, well hydraulics, Darcy's law for porous media.
- Students will learn the concepts of flow and transport equations for different type of contaminants, porous medium.
- Students will develop the numerical models for ADE, MIM and MPNE and will simulate the observational data from literature.
- Students will also learn the concepts of relating the numerical model with field conditions.
- ***Course Outline:***
- Groundwater flow and simulation will be a theoretical and numerical subject with development of analytical and numerical solution to the various groundwater contamination problems.

- Students are required to develop numerical model any of the programming language (FORTRAN, C, C++ or MATLAB)
- ***Modules:***

Sr No	Contents	Contact Hours
1	**Introduction**: Hydrologic cycle, Subsurface flow and basics, Darcy's law, emphasizing the role of groundwater in the hydrologic cycle, different types of aquifer and flow properties, types and sources of contamination.	2
2	**Flow through Porous Medium:** Flow through filters and soil columns, fractured and stratified porous medium**.**	2
3	**Groundwater Flow Equations:** conceptual development of flow equations, derivations of flow equations for groundwater flow through homogeneous and heterogeneous porous medium, application of Darcy's law.	4
4	**Groundwater Transport Equation:** Development of contaminant transport model in homogeneous and heterogeneous porous medium, Flow parameters identification and estimation.	6
5	**Development of Solution:** Numerical methods to solve flow and transport equations, solution of ADE, MIM, MPNE.	6
6	**Field application of Transport equations**	6
	Total	28

Groundwater Lab

1) Experiments for reactive and nonreactive solute transport through porous media
2) Estimation of equilibrium sorption coefficients of various reactive solutes using linear and nonlinear isotherms
3) Inverse problem for source identification
4) Rainfall runoff simulation for surface and groundwater interaction

Suggested Books:

a) Zheng, Chunmiao, and Gordon D. Bennett. Applied contaminant transport modeling. Vol. 2. New York: Wiley-Interscience, 2002.
b) Yong, Raymond Nen, Abdel-Mohsen Onsy Mohamed, and Benno P. Warkentin. Principles of contaminant transport in soils. Elsevier Science Publishers, 1992.
c) Todd, David K., and Larry W. Mays. Groundwater hydrology edition. Wiley, New Jersey, 2005.

Reference:

d) Bear, Jacob, Chin-Fu Tsang, and Ghislain De Marsily. Flow and contaminant transport in fractured rock. Academic Press, 2012.
e) Grathwohl, Peter. Diffusion in natural porous media. Kluwer, 2002. Dagan, Gedeon. Flow and transport in porous formations. Springer-Verlag GmbH & Co. KG., 1989.